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## **Optical Monitoring of GRO Phase 1 Objects**

**Bernard McNamara, Jack Burns, William Webber**

**New Mexico State University**

### **Abstract**

This paper presents a brief overview of the three phases of our GRO/optical monitoring program: 1) the acquisition of simultaneous GRO/optical data on targeted OSSE objects, 2) the collection of noncoincident observations of suspected GRO gamma-ray emitters to determine their current level of activity, and 3) the optical imaging of burst fields in an attempt to identify the burst source. Finally a table of future simultaneous optical observations of Phase I GRO targets is presented along with plans for the rapid optical imaging of gamma-ray burst fields.

### **Introduction**

This paper describes our optical monitoring program as of mid-September 1991. Results are presented in four sections:

- 1) a discussion and graphical presentation of the optical behavior of Cyg X-1 and 3C273 during the time these sources were observed by GRO/OSSE,
- 2) noncoincident database measurements of the targeted GRO/OSSE discrete sources Sco X-1 and NGC 4151,
- 3) an example of the optical image of a recently detected GRO burst field, and
- 4) plans to optically observe other targeted GRO objects and burst sources at the NMSU Blue Mesa Observatory and ARC Apache Point Observatory.

### **Coincident Ground Based Observations of Cyg X-1 and 3C273**

Cyg X-1 was originally targeted to be observed by GRO/OSSE from 30 May 1991 to 13 June 1991. Observations of this object were interrupted when the spacecraft was redirected to a target of opportunity. It was therefore not possible to obtain as much coincident data as was originally planned. Our photoelectric data was obtained using the 24-inch reflecting telescope and unfiltered single channel high speed photometer at the New Mexico

State University Blue Mesa Observatory. Cyg X-1 optical measurements were obtained on the nights (U.T.) of:

May 29, 1991  
May 30, 1991  
May 31, 1991  
June 1, 1991  
June 3, 1991  
June 4, 1991  
June 5, 1991  
June 6, 1991  
June 7, 1991  
June 8, 1991

Data reduction is continuing. Some results are presented in Figure 1 in the form of a light curve. Typically Cyg X-1 was observed using an integration interval of 0.1 second. To reduce scintillation noise, measurements have been collected into 5 second bins. A power spectrum of the partially reduced data does not indicate any short term periodicity. Since Cyg X-1 is a HMXB, the high energy source would have had to produce a significant optical flux in order to be detectable against the primary 09.7 Iab star.

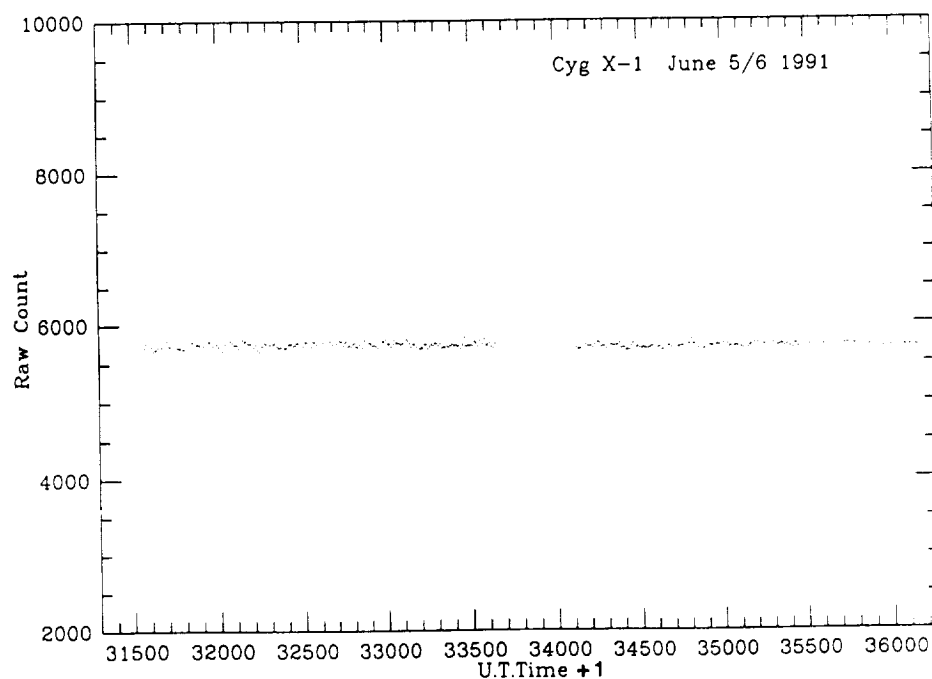


FIGURE 1 - Example of a partial light curve for Cyg X-1 obtained during June 6, 1991 U.T. using the NMSU Blue Mesa Observatory 24 inch telescope and a high speed photometer. The Y axis represents unfiltered, normalized raw counts. The X axis is U.T. + 1 hour.

Once the spacecraft was redirected, GRO/OSSE obtained observations of 3C273. We had already collected some baseline data on this target and once notified of the scheduling change, it was placed back on our observing list. Unfiltered photoelectric measurements of 3C273 were thus acquired on the nights (U.T.) of:

May 30, 1991  
June 1, 1991  
June 4, 1991  
June 16, 1991  
June 17, 1991  
June 18, 1991  
June 19, 1991

No erratic optical behavior from this source was detected.

#### **Noncoincident Database Measurements of Targeted GRO/OSSE Discrete Sources**

As time permitted, other noncoincident optical measurements at Blue Mesa were obtained of two other GRO/OSSE targets: Sco X-1 and NGC 4151. The intent of these observations was to provide an activity baseline which could be useful in the interpretation of upcoming GRO/OSSE observations. The U.T. dates of these optical observations and an example of the activity seen in Sco X-1 are given below and in Figure 2.

<u>NGC 4151</u>	<u>Sco X-1</u>
May 31, 1991	June 1, 1991
June 3, 1991	June 4, 1991
June 7, 1991	June 6, 1991
	June 8, 1991
	June 16, 1991
	June 18, 1991

## Future NMSU Optical GRO Support

with J. Ryan and G. Fishman

### **A) Upcoming Simultaneous Optical Observations of GRO/OSSE Targeted Fields**

Our plan is to obtain high time resolution coincident photoelectric measurements of the following GRO/OSSE objects to search to periodicities or correlated gamma-ray/optical transient events.

GRO Run 15 28 Nov. 1991 - 12 Dec. 1991	NGC 1275 and Cyg X-1
GRO Run 19 23 Jan. 1992 - 06 Feb. 1992	M82

### **B) NMSU Attempts at Locating the Optical Counterparts of Gamma-Ray Burst Sources**

Despite many attempts to detect the optical counterpart of a gamma-ray burst, we still lack a positive source identification. The optical detection of a gamma-ray burst source would therefore be of great interest.

We have begun to experiment with a scheme which utilizes the fast response time of the ARC (Astrophysical Research Consortium) telescope located at Apache Point, NM to search for the optical counterparts of these transient events. Our plan is to obtain deep CCD images of localized (<10 arcmin) GRO burst fields in an attempt to identify the source. Each burst field would be imaged using 4 CCD frames. Observations would be obtained in both the visual and red and then repeated as part of a continuing monitoring program. The CCD images will then be examined for unusual stellar objects, colors, or variability. We anticipate that the entire exposure sequence could be obtained using less than one hour of telescope time. Below is a reproduction of an ARC telescope (using its temporary 1.8 meter mirror) 15 minute CCD R image of a burst field detected by GRO on June 1, 1991. Coordinates were kindly provided to us by J. Ryan (UNH). This image was compared to the Palomar Sky Survey R print. No peculiar object or obvious differences between the stars seen on the PSS and the CCD frame are apparent. The image presented here is primarily intended to demonstrate our current optical capability. We anticipate further improvements in this process in the near future.

## Summary

As of the end of mid-September 1991 coincident optical observations have been obtained for two targeted GRO/OSSE objects: 3C273 and Cyg X-1. No unusual photometric activity was noted from either of these sources. Additional observations of the activity present in NGC 4151 and Sco X-1 were obtained. One newly discovered GRO burst field has been imaged. No obvious burst candidate was found but only the central region of the gamma-ray error box was examined. As smaller error boxes become available due to refinements in GRO data analysis and/or additional information becomes available from other satellites this effort will be expanded.

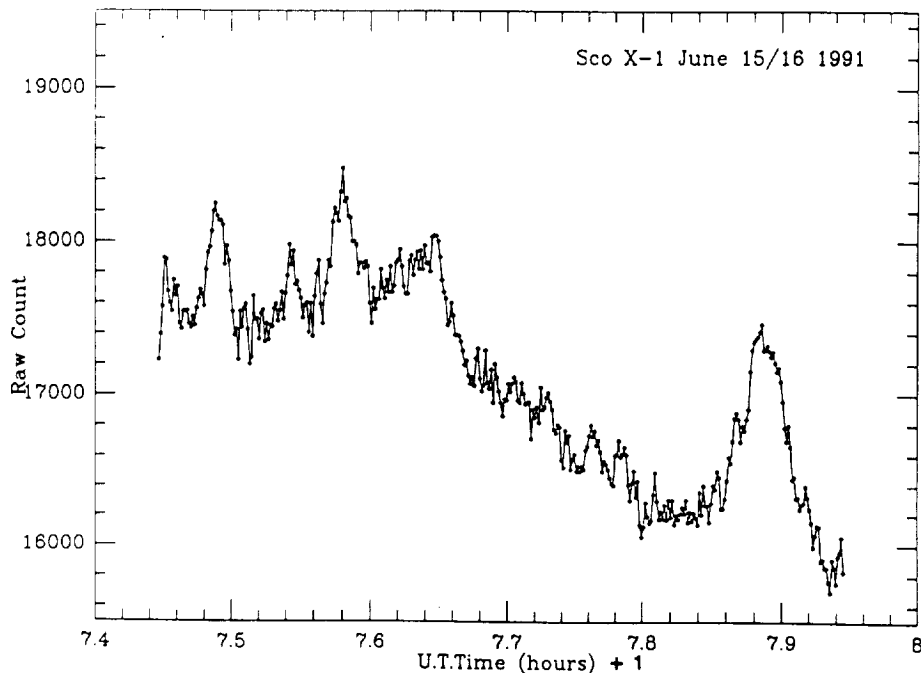


FIGURE 2 - Example of a partial light curve for Sco X-1 obtained on June 16, 1991 U.T. The Y axis represents an unfiltered, normalized raw count and the X axis is U.T. + 1 hour. Both flickering and flaring activity is evident.

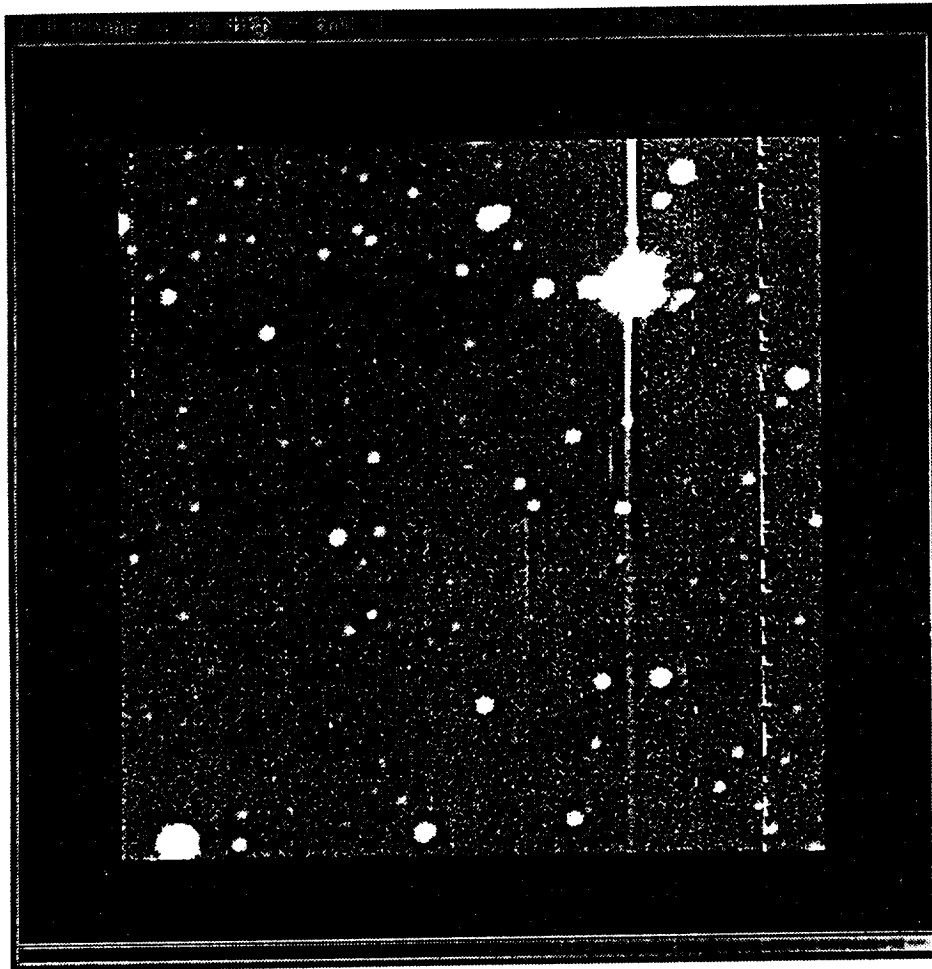


FIGURE 3 - CCD R image of the central region of the June 1, 1991 GRO burst error box. The 15 minute CCD image was obtained using the ARC 1.8m telescope. The imaged area is  $\sim 3' \times 3'$ . The telescope coordinates where  $\alpha(2000) = 20^{\text{h}} 36^{\text{m}} 53^{\text{s}}.9$ ,  $\delta(2000) = 30^{\circ} 47' 31''.28$ .